Hydraulic Lifelines for Soil, Water, and People

In the United States, the drought of the 1930s was followed by periodic flooding in the 1940s and early 1950s. These events, plus the postwar baby boom, its accompanying housing boom, and other developments, made America's agricultural community keenly aware of its responsibility for stewardship of the soil and water resources needed to meet increasing demands for food and fiber.

USDA responded in a number of ways to allow farmers and others to maintain future resources while increasing food and fiber production throughout the last half of the 20th century.

Federal research on hydraulic structures and engineered stream channels has played a major role in America's food success story and our farmland's sustainability. In particular, the ARS Hydraulic Engineering Research Laboratory at Stillwater, Oklahoma, is recognized worldwide for modeling, designing, and evaluating hydraulic structures.

This year, the lab celebrates its 60th anniversary. Throughout its history, ARS hydraulic research has played a major role in developing the knowledge and procedures for successfully and economically designing and constructing different structures for alleviating flooding and controlling erosion.

The 1930s-era droughts across the central United States made clear the need to keep water and soil in place. To this end, many thousands of acres of cropland have been terraced. Most terraces are drained by grassed waterways designed to convey excess water to stream channels without erosion. An estimated half-million miles of these channels have been constructed in the United States and elsewhere. Most, designed over the past 50 years, use engineering criteria developed and tested at Stillwater.

Natural processes, changes in land use (especially from development), and dredging combined to make some stream channels unstable. Eroding streambeds and banks destroy land and move excess sediment downstream. Stream-stabilizing structures are often required to control bed erosion and let trees, grasses, and other vegetation anchor the banks. These measures, properly applied, allow people to productively share the floodplain with the rest of the ecosystem.

Floods can cause extreme destruction to cropland and river environments. In many areas, especially the central United States, seasonal thunderstorms can dump very large volumes of water on small watersheds.

To protect lives, property, and transportation and communication systems, the nation has invested about $14 billion in an infrastructure of upland flood-control reservoirs built with assistance from USDA and similar watershed programs. The purpose of these reservoirs is to temporarily contain floodwater and release it at a rate the downstream channel can hold.

Each year, the return on this investment—in preventing property and crop losses—is estimated to exceed $800 million. Besides reducing flooding and sedimentation, the reservoirs provide recreational fisheries, wildlife habitat, and wetlands above the containment.

Each upland flood-control reservoir consists of multiple components. Each component is a hydraulic structure that must operate properly if floodwaters are to be controlled.

Flow to the downstream channel is conveyed by a principal spillway—usually a pipe—through the reservoir. Often, trash racks are needed to prevent floating flood debris from clogging the pipe's inlet. ARS scientists have designed, developed, and tested many inlets and trash racks used worldwide.

To prevent damage to a floodplain below the reservoir, the tremendous energy of the large volume of water released from a reservoir must be dissipated before it enters the downstream channel. This is done with a stilling basin at the spillway's outlet. The most common type of stilling basin is the riprap-lined plunge pool into which water drops as it exits the pipe. Both the pool and its protective lining of stone riprap must be properly sized.

It is generally impractical to provide reservoir storage for extremely large and infrequent floods. On most watershed flood-control structures, an auxiliary spillway safely diverts these large flows around the dam. These spillways are usually wide, steep, grass-lined channels. The channels must be properly sized to convey the maximum amount of water without eroding the spillway and causing it to fail. The Stillwater laboratory has developed exacting design criteria for these vegetated channels.

Still, in some instances a vegetated spillway is impractical. Instead, structural spillways—usually concrete-lined channels—are used. These spillways must be properly designed to dissipate the water's energy before the flow returns to the downstream channel.

Many stilling basin designs are available. But the Saint Anthony Falls stilling basin, developed more than 50 years ago by USDA hydraulic engineer Fred W. Blaisdell, is still recognized worldwide as one of the smallest, most efficient, and most economical designs for dropping water level.

Thousands of flood-control structures were built from the late 1940s through the 1990s. Many were designed for 50 years of service and are near the end of their planned life. Rehabilitating and upgrading them poses new technical challenges. ARS scientists will meet these challenges while protecting the environment and agriculture.

Darrel M. Temple
Research Leader, Hydraulic Engineering Research Laboratory
Stillwater, Oklahoma